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The Use of Insecticides in Hawaii

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INTRODUCTION.

The agriculturist has always to contend with insect pests, which destroy or injure his crops. This is in the nature of things, as insects are largely phytophagous. Were it not indeed for the fact that parasitism is general within the class, a ruinous condition would soon result. It is difficult to estimate the losses occasioned by insects, but they must in the aggregate be enormous. To prevent or mitigate them is largely a practical problem in which both entomologist and agriculturist are concerned. The more practical aspects of the subject are already familiar to the grower through experience, and the purpose of the present paper, which deals principally with the insecticides which have come into general use in Hawaii, is merely to bring together the available information for the benefit of all.

ARSENICAL INSECTICIDES.

Arsenical insecticides kill by poisoning and are intended to be ingested by the insect. They are the most widely applicable of all the insecticides, but are only useful for insects with biting mouthparts. The following are some of the leading arsenical preparations:

Revision of Bul. 3—out of print.

Arsenate of Lead. Arsenate of lead may be applied to plants in the form of a spray with water as a vehicle, or in a powdered form may be dusted on. Both forms can be bought on the market ready-made, or they can be made at home. They are generally useful for defoliating insects and the young stages of stem borers and leaf rollers. Prepared arsenate of lead is applied at the rate of 3-15 lbs. to 100 gallons of water. To prepare arsenate of lead from its components, use 3 parts of pulverized arsenate of soda to 7 parts of pulverized acetate of lead. These dissolved in warm water and united form a white precipitate which should be kept covered with water until desired for use. The powdered arsenate is probably more easily and cheaply applied to some plants and is more effective for some insect pests, the boll worm for instance.

Paris Green. Paris green sometimes forms a substitute for asenate of lead and if a guaranteed brand and mixed with lime is just as effective as lead arsenate and perhaps cheaper. The caustic properties of paris green (due to the free arsenious acid it contains) makes its use more or less unsafe and the lime is added, usually in equal proportion to the paris green, to overcome its tendency to burn. Paris green is applied at the rate of 1 lb. of paris green to 100-250 gallons of water. It is also sometimes dusted onto plants, but is then apt to burn.

White Arsenic. White arsenic is used only in insect baits. The bait is prepared by mixing arsenic and bran, middlings or flour, with the addition of thin molasses. The proportions are 1 lb. of arsenic to 20-50 lbs. of bran. Spread in the field, around the plants if desired but not so near to them that the arsenic dissolved by the rain will burn them. The arsenic is also sometimes mixed with freshly cut alfalfa or sorghum and distributed over the fields to bait insects. Baits are very useful in Hawaii in coping with cutworms, army worms, and wireworms.

PETROLEUM INSECTICIDES.

Petroleum insecticides act by external contact, causing irritation and interfering with the vital functions of the insect. Their use is confined largely to insects with sucking mouthparts, which

cannot be effectively reached with poisons, and to aquatic or semi-aquatic larvæ. The following are some of the petroleum insecticides:

Kerosene Emulsion. Kerosene emulsion is usually applied to infested plants in the form of a spray, and is the standard remedy for attacks of plant lice, scale insects and leaf hoppers. In preparing the mixture, a "stock" emulsion is at first secured, which will keep several weeks, and the necessary dilution is made at each application. To prepare the stock, dissolve one-half pound of whale-oil soap in a gallon of water over a fire. Remove while hot to a safe distance and add 2 gallons of kerosene, stirring vigorously until the oil and soap solution are thoroughly emulsified. This is diluted with 15-20 times the quantity of water before applying it to the plants.

Miscible Oils. Miscible oils are mostly proprietary compounds which mix directly with water. There are many of these on the market and they are mostly good, though more expensive than home-made kerosene emulsion. They save time and bother, and where but a small amount of spraying is to be done are perhaps cheaper.

MISCELLANEOUS INSCTICIDES.

Soap. Castile soap dissolved in water is often used to kill plant lice and scale insects, especially when the infested plants are small and more or less personal attention can be given to the application. The soap is dissolved in hot water and the application made while the solution is still warm. Use 1 lb. of soap to 1-2 gallons of water.

Tobacco. Tobacco is often used as an insecticide and is fairly effective against plant lice, mealy bugs and other soft-bodied insects which can be killed by an external irritant. It is a cheap remedy, as the tobacco is largely waste from tobacco factories. It is applied as a spray from infusions or decoctions of tobacco stems, or the powdered tobacco scrapings are dusted onto plants after they have been moistened, or in the early morning or late evening while the dew is on them. Infusions or decoctions of

tobacco are often mixed with petroleum or other compounds to enhance their insecticidal value. There are many proprietary preparations of tobacco on the market, which are ready for use directly when mixed with water, and save most of the trouble of preparation. To make a tobacco decoction at home steep tobacco (stems usually) in an amount of water sufficient to cover them and when the active principle has all been extracted, strain and dilute the liquid taken off with water until it has an amber color, when it is ready for use.

Sulphur. Sulphur in the form of flowers of sulphur is valuable as an insecticide for thrips and red spider. It is used a good deal in greenhouses, where it is evaporated in a sand bath over an oil stove, or it may be applied directly to plants as a powder. Sometimes it is mixed with water at the rate of 1 ounce to the gallon of water; or the plants may first be moistened and the sulphur dusted on.

Pyrethrum. Pyrethrum powder or buhach is commonly used here as a repellant for mosquitoes. The powder is obtained from the flower heads of a composite plant, *Pyrethrum cinerariaefolium,* and owes its value as an insecticide to the presence of an oil which is poisonous to insects when they can be reached by it. To free a room of mosquitoes, a small amount of the powder is spread directly upon coals, or made into small pills by wetting and moulding with the hands and then set on the coals. It is also useful in destroying plant lice or thrips on small plants and may be applied as a spray when dissolved in water at the rate of 1 ounce to 3 gallons or dusted onto plants after diluting it with from six to twenty parts of flour.

INSECTICIDAL GASES.

Hydrocyanic acid gas and the fumes of carbon bisulphid have now come into rather general use as insecticides, the former in the treatment of fruit trees or smaller plants badly infested with plant lice, mealy bugs, scale or other insects, and both in treating infested foodstuffs, seeds, plant stocks, furniture or other material which can be enclosed in an air-tight compartment and sub-

jected to the action of the gas. The fumigation of orchard trees or garden plants with hydrocyanic acid gas requires a covering for the plants to retain the gas. These are usually made in the form of a tent of stout canvas soaked in oil or cactus juice, or in the form of a box, the frame of which is covered with cloth similarly saturated with oil. Seeds, plant stocks, furniture, and other material can be most economically fumigated in an air-tight receptacle or compartment of suitable dimensions, and if much fumigation is to be done, a fumigating box or house should be specially constructed with the idea of convenience in placing the "charge," storing the material, and ventilation. Mills, warehouses and storerooms can usually be fumigated when infested by covering windows and doors and stopping up cracks and other sources of leakage with paper pastings.

To generate hydrocyanic acid gas, cyanide of potassium, sulphuric acid and water are used in the proportions of 1 ounce of cyanide to 1 fluid once of acid and 3 of water. An earthenware vessel should be used. First pour in the water, then the acid, and do not add the cyanide until everything is ready for the generation of the gas. For general purposes, use 1 ounce of cyanide with the proper amount of acid and water, per 100 cubic feet. The gas is lighter than air and diffuses rapidly, so that ample allowance must be made for leakage.

The fumes of carbon bisulphid are better than hydrocyanic acid gas for some purposes. They are heavier than air and far more penetrating. The liquid also is much more easily handled. It is therefore preferable for fumigating small lots, for grain and seeds, which usually pack closely, and for use about houses. It is also useful for ground-inhabiting insects, root-maggots and root worms, root-feeding aphids, ants, borers, &c. In air-tight compartments it is used at the rate of 1 pound per 1,000 cubic feet. For ants, a teaspoonful poured into the opening of the nest will usually destroy all the ants in the nest. For root forms, 5 ounces per plant are necessary, and usually several successive applications.

SPRAYING TO KILL NOXIOUS WEEDS.

This subject, while somewhat foreign to the present paper, is one on which information is frequently desired. Two compounds have been used with some success here—ferrous sulphate and arsenite of soda. Arsenite of soda for weed-killing is prepared as follows: 2 lbs. of white arsenic and 6 lbs. of lime are dissolved in one gallon of water and boiled for fifteen minutes. Dilute one pint of this mixture with ten gallons of water, when it is ready for use. Ferrous sulphate dissolves in water and is used at the rate of 3 lbs. of sulphate to 1 gallon of water.

MATERIALS AND EQUIPMENT.

Insecticidal materials and spraying apparatus can be procured from dealers in Honolulu or directly and through agencies from wholesale houses on the mainland. The National Insecticide law insures to a certain extent the validity and purity of insecticides. The insecticide to use will depend on the identity of the insect pest and the nature of its injury, and in this regard assistance from the experiment station is always at the command of the agriculturist. The variety and uses of different spraying devices make the recommendation of any one impossible. The grower can determine from catalogues and descriptions the apparatus most useful for his purposes. Mechanical simplicity in the pump and a nozzle that will give an exceptionally fine spray seem to be desirable features in a machine here.

PRACTICAL REMEDIES FOR COMMON PESTS.

Red spider, Thrips—Dust the leaves or fruit with powdered flowers of sulphur after moistening to make the powder adhere.

Ticks—Ticks on domestic animals should be dislodged by hand and killed in kerosene. Zenoleum sprayed with considerable pressure on fowls, cattle, &c., will assist in keeping them free of ticks and mites.

Book lice—Book lice in stored material may be readily killed with chloroform.

Cockroaches—Cockroaches may be exterminated in houses by spreading out at night cockroach poison—usually a mixture of phosphorous and molasses.

Aphis—Spraying with petroleum mixtures or tobacco decoction will often reduce aphids when they are exceptionally abundant. The predaceous Coccinellid beetles usually keep them well in check.

Grasshoppers—Spray plants being damaged by grasshoppers with arsenical poisons.

Mealy bug, Flat scales, White fly, Leaf hopper—Spray infested plants with petroleum mixtures or tobacco decoctions, or fumigate with hydrocyanic acid gas. The white flies are also attacked by parasitic fungi.

Wood borers—Wood-boring beetles and the carpenter bee are prevented from destroying timbers by soaking the timbers in carbolineum, which acts as a repellant.

Cigarette beetle—Cigarette beetles in tobacco products are controlled by fumigation with hydrocyanic acid gas.

Japanese beetle—To reduce the injuries of Japanese beetle, when severe, a combination of the following remedies is recommended: hand-picking at night, poisoning with an arsenical spray, the use of the Japanese beetle fungus, and plowing or spading the turf in the vicinity of the injury to disturb the larvæ.

Potato flea beetle—Spray with arsenical poisons.

Bean weevils—To reduce bean weevils in stored beans, fumigate with carbon bisulphid. Weevils in stored products should be similarly treated.

Mosquitoes and house flies—Relief from the adult fly can be secured by screening, burning buhach powder, or trapping the flies. The larvae of the mosquito can be killed by draining the water in which it breeds or covering the surface of the water with a film of petroleum. Duckweed and *Azolla* have also been used to choke the surface of the water. The nuisance of the house fly may be abated, where its breeding-place can be controlled, by spreading out stable manure in which they breed on the ground.

Horse bots—The eggs should be removed from the horse's legs by brushing and washing with solution of carbolic acid.

Cow bots—Cow bots should be removed from cows' backs by pressure with the hands.

Dung flies, Filth flies—Dung flies and filth flies may be suppressed by either removing the material in which they breed or treating it with petroleum.

Horn fly—Horses and cattle may be relieved temporarily of horn fly by spraying them with zenoleum. The manure of the animals, in which the flies breed, should be spread out on the ground.

Melon fly—The only practical suggestion with regard to the melon fly is to protect fruits, where possible, with paper bags.

Boll worm—To reduce boll worm infestation, dusting with powdered arsenate of lead, picking and destroying infested bolls and fumigation of stored seed cotton are recommended.

Potato tuber moth, Tobacco split worm—Spraying with arsenate of lead, clean culture, the fumigation of stored potatoes with carbon bisulphid are recommended.

Angoumois grain moth—Fumigation of stored grain with carbon bisulphid is recommended.

Cabbage moths, Cabbage butterfly, Sphinx moths, Leaf rollers—Spraying with arsenate of lead will reduce the damage caused by these defoliators.

Ants—Ants can be destroyed in their nests by pouring into the entrance a teaspoonful of carbon bisulphid.

Phycitid moths in stored foods—Fumigation with carbon bisulphid or hydrocyanic acid gas is recommended to reduce an infestation by these pests.

Cutworms, Army worms—Baits of sweetened bran and arsenic, spread around individual plants or in rows about fields, are recommended for cutworms and army worms.

Sweet potato stem borer—Clean culture, the destruction of plant rubbish and discarded potatoes after harvest.